

FURTHER STUDIES ON THE DELAYED PECKING OF
CHICKS

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DISSERTATION

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I. INTRODUCTION

This is a further experimental contribution on the question concerning the parts played by maturation and practice in the development of the pecking reaction in chicks. In presenting it, we shall assume that the reader is familiar with the work of Shepard and Breed (1), Moseley (2), and Bird (3, 4); but it is necessary to emphasize certain specific facts in order to state the problem of the present investigation.

In the first place, the original suggestion of Shepard and Breed was that maturation determines an upper limit of efficiency, rising for some days with the age of the animal, but that a certain minimum amount of practice, yet to be determined, is required to reach and hold that limit. In relating Bird's experiments with limited practice to this suggestion, one must conclude that Bird's limit was too low. If practice be delayed up to four days beyond the beginning of tests for the no-delays, "two days" only of practice seemed necessary to reach the maximum of which the no-delays were then capable.

A point of great importance is that Shepard and Breed hatched the chicks in the dark and kept them in complete darkness at all times until the tests began. The forced-feeding was done in the dark, and care was taken to place the food pellets far back in the mouth before the head was released to allow the chick to swallow. In contrast, both Bird and Moseley force-fed in the light, which would probably make more possible the setting up of interfering habits.

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Another point to be noted is that all previous investigators have used samplings only of performance as a measure of progress and have known nothing of amount or accuracy of practice other than the samplings. Shepard and Breed used samplings of 50 pecks, Moseley samplings of 20, and Bird samplings of 25.

The following problems suggested themselves as the main tasks of this investigation.

Shepard and Breed with all groups of chicks, and Bird with his group D, and less definitely with group B, found a rapid rise when natural feeding began after the period of delay. Was this rapid rise real or merely apparent? It might be partly apparent because of possible difference in the amount of practice of the normal and delayed groups; or it may be apparent because of the inadequacy of samplings to express the real progress. In this connection, it is a question whether the "normal" curve, based upon samplings, gives a true picture of progress. Also, is any composite curve of many individuals sufficient alone to represent the course of development? Such questions suggest the need of a complete record of all pecks of each individual under varied controlled conditions. This would make possible significant curves of individual progress. What would be the result of different fixed numbers of pecks, similar to Bird's limited groups, but with other fixed amounts and with the chicks otherwise kept and fed in darkness? With such complete control of conditions, what is the effect of more widely varied periods of delay? This paper offers results which partially answer the above questions. The research was carried on during the winter of 1928 to 1929, through the summer and fall of 1929, at the Psychological Laboratories of the University of Michigan. The writer is indebted to Professor John F. Shepard for his guidance throughout the investigation.

II. TECHNIQUE

The chicks used in this investigation were mixed White Leghorns and Plymouth Rocks. Since the results showed no distinguishing difference between the performances of the two kinds of chicks, no attempt was made to indicate the number of each

in the different groups. The chicks were hatched in an electric incubator. In order to make sure that the chicks saw no light until brought to the testing table, the incubator was placed in a dark room inside another dark room. To insure absolute darkness, at the eighteenth day of incubation, the door of the incubator was made light-tight by sealing the glass window. Because previous investigators had reported that chicks do not peck much during their first twenty-four hours after hatching, the chicks were allowed to harden in the incubator for twenty-four hours and were then carried in complete darkness to the brooder where they were kept, and from which they were brought out to be tested.

The brooder was a large dark room approximately 9 by 12 feet. The room is completely dark, and is entered only through another dark room of the same size which was used as the feeding room. The feeding room itself was entered from the testing room through a short vestibule with double doors, so that no ray of light entered either the feeding room or the brooder. Except for ordinary room temperature, the feeding room was not heated, and was separated from the brooder by a door which was kept closed. The brooder was entered only in total darkness, and the experimenter had to learn to grope his way in the darkened brooder.

The brooder was electrically heated. An electric thermostat suspended from the ceiling controlled the amount of heat and kept the temperature constant between 92° and 97°F.

On three sides of the brooder room were built double-decked stands on which were arranged 20 individual boxes 12 by 12 by 12 inches. These boxes were made of smoothly planed boards $\frac{1}{2}$ -inch thick. All the chicks used in this investigation, except as otherwise stated, were kept in these boxes, each chick isolated from all others throughout the experiment. When the chicks were brought from the incubator they were assigned each to one of the boxes. Thus the chicks were kept in absolute darkness during their period of confinement, and were prevented from pecking at each other, and also from pecking at wire meshed enclosures. In short, there was no possibility of the chicks peck-

ing at anything to afford them practice, except perhaps pecking against the hard surface of their boxes. These conditions having been met, there yet remained the problem of forced-feeding. The method of feeding used was precisely that employed by Shepard and Breed. All the forced-feeding was done in the dark, and the pellets of food were placed far down into the throats of the chicks so that only the swallowing reaction could follow. The liquid diet was introduced into the throat by means of medicine droppers, care being taken that the chicks did not bite the pipette.

The chicks were not fed during their first twenty-four hours in the incubator. When brought to the brooder they were given only buttermilk during the first day of testing. All forced-feeding started thirty-six hours after hatching. The diet consisted of a mixture half and half of McCollum's rat diet and chick mash moistened with buttermilk or sour milk, with a small amount of cod liver oil. The latter was added to their diet in order to prevent possible deleterious effects of darkness. Instead of water all the chicks used in the experiment were given buttermilk, and occasionally sour milk. Grit was force-fed to all the chicks once a day, the chicks being fed twice a day, morning and evening. The amount of food given each chick was regulated by feeling the crop of the animal.

The testing room was a large room adjoining the brooder and feeding room. When the chicks were very young, they would not peck when they were chilled, so the testing room had to be heated to approximately the same temperature as the brooder room. This was done by raising the temperature of the room with the steam radiator, and in addition using two electric heaters, thus bringing the room temperature to about the same as that of the brooder. When the chicks had sufficiently grown, the temperature of the testing room was kept at about 88°F.

Two types of testing tables were used. One was a table 30 by 48 inches over which a dull black oil cloth was placed. The other table had a black cardboard 22 by 24 inches. A mirror was suspended against the wall near this second table in order to facilitate observation. No difference was found with regard to

the use of the two pecking tables, so no distinction is made in this report as to which table was used. Care was taken to keep the pecking tables spotless. Light was supplied from ordinary daylight which came through the south and west windows, and supplemented by the light from a 75-watt table lamp which was placed on the table. When tests were taken in the evening, two ceiling lights of 150 watts each and the table lamp furnished the light necessary for the experiment.

The grains used in the testing consisted of cracked corn and wheat. In order to have the grains of uniform size, these were passed through a wire sieve of $\frac{1}{8}$ -inch mesh. During the first three days of testing when the chicks were just beginning to peck, the grains were placed on the table indiscriminately, but with the grains no nearer than an inch from each other. When the chicks had acquired a high rate of accuracy, the grains were placed one at a time, to enable the experimenter to take an accurate record. This was done merely because, during the first few days, the chicks were slow to peck, whereas, after they had learned to peck accurately, they pecked fast.

The same method of recording the pecking responses employed by previous investigators was used in the present experiment; that is, reaction number 1 for missing, or failing to hit the grain; 2, striking, or hitting the grain but failing to seize it; 3, seizing, or holding the grain in the bill but failing to swallow it; and 4, swallowing, or the completed reaction. Only pecks directed at the grains were recorded in this experiment. Sometimes chicks, especially the delayed ones, pecked at dots or at the surface of the table generally, without apparently aiming at grains. Such pecks were not recorded. Occasionally a delayed chick performed a drinking reaction on the table and accidentally brought its bill close to a grain without apparently aiming at it. Such pecks were also excluded from the records. It was felt that such reactions could not be included under the term of practice since they were not reactions to the grain.

With the exception of certain groups of chicks whose complete records of pecking were taken, all the pecking records of the chicks were taken regardless of the sequences of the pecking reactions;

that is, the number of different reactions were simply counted regardless of the sequence in which they came. With those groups where a complete record of pecks was desired, the pecking reactions were taken down in the exact sequence in which they came.

When a chick was ready to be tested it was at first brought out to the light and placed in a light box under a 75-watt lamp for light adaptation for five minutes; but it was found later that the period of inactivity of the chick when brought to the testing table enabled it to become light adapted, so the earlier plan was abandoned. The chick was simply brought from the dark room and placed on the table and given grains to peck at.

III. DESCRIPTION OF TECHNIQUES USED IN THE DIFFERENT SERIES AND GROUPS OF CHICKS

A. *The limited series*

The chicks used in the *limited series* were given only 75 practice pecks daily and force-fed the remainder of their food in the morning after their test and in the evening. Except during their test period in the morning they were kept in the dark brooder, each in a separate box. Force-feeding was done in the dark in a manner previously described. The chicks were divided into four groups: the no-delay, the 4-day delay, the 8-day delay, and the 14-day delay. During the periods of delay, all food required was force-fed.

The no-delay chicks were those which were started as soon as they were removed from the incubator. Since they were allowed fully twenty-four hours for hardening in the incubator, their first test was not taken until the beginning of their second day after hatching. Hence they were really one day old when they were tested. Those in the 4-day delay group were delayed four days beyond the no-delay group, so that they were not tested until the beginning of their sixth day after hatching. The chicks in the 8-day delay group were also delayed eight days beyond the no-delay group, and were tested at the tenth day. The 14-day delay chicks were not tested until the sixteenth day after hatching. These statements must be borne in mind when we refer to those

delayed groups in order not to confuse the age of the chicks with the number of days they were delayed.

B. The unlimited series no. 1

In order to compare the pecking responses of chicks which were allowed only 75 daily pecks with those which were allowed an unlimited amount of practice pecks, we took a series of chicks which we divided into groups similar to those in the Limited Series. In this series each chick was allowed as many pecks as it cared to make in every test, being tested twice a day, morning and evening. However, no attempt was made to separate the morning and evening pecks, so we simply recorded the total number of pecks for the day. The chick tested was brought to the table and given grains to peck at and a record of the reactions made was taken regardless of the sequences of the pecks. When the chick was satisfied, it was given milk and returned to the dark brooder where it was kept until brought out again for the next test. Except for this difference in the amount of practice the chicks in this series were treated in the same manner as those in the limited series.

C. Unlimited series no. 2

In the course of taking records of chicks in the unlimited series no. 1, it was discovered that during the test the chicks would become fatigued, that is, they soon reached a point where they merely pecked the grains and deliberately dropped them. This obviously lowered their records somewhat. It was also noticed that there was some evidence of warming up, since the chicks pecked with higher accuracy in the evening than they did in the morning. In order to get a more accurate record of their pecking responses, and also to find if there was any real evidence of warming up, we took another series of chicks (unlimited series no. 2) and gave them an unlimited amount of practice as in the first series, with the exception that a complete record of each chick was taken; that is, all the pecks were recorded in the order as they were given by the chick. We also took separate records for each of the three daily tests, morning, afternoon, and evening.

Only two groups were used in this series, the no-delay and the 8-day delay.

In order to facilitate the identification of the different groups in our discussion, we shall refer to the limited series as the L-series, and the groups in the limited series as the NDL, 4DL, 8DL, and 14DL, which stand for the no-delay, the 4-day, 8-day, and 14-day delay groups respectively. Similarly, we shall speak of the unlimited series no. 1 as the S-1 series, and the corresponding groups as the NDS1, 8DS1, and 14DS1. The two corresponding groups in the unlimited series no. 2 are the NDS2 and the 8DS2.

TABLE 1
Number of chicks used in the experiment

A. LIMITED SERIES		B. UNLIMITED SERIES NO. 1		C. UNLIMITED SERIES NO. 2		D. CHICKS EXPOSED TO LIGHT	
Group	Chicks	Group	Chicks	Group	Chicks	Group	Chicks
NDL	12	NDS1	13	NDS2	10*	8DE	2
4DL	10	4DS1	12	8DS2	8*	14DE	5
8DL	12	8DS1	9				
14DL	21	14DS1	5				

*One not normal.

D. Chicks exposed to light

Two other groups may be mentioned which were treated in somewhat different ways from the others. The 8DE and the 14DE groups stand respectively for two groups of chicks which were delayed eight and fourteen days as in the case of the other corresponding groups. However, these chicks during the course of their artificial delay and force-feeding were brought to the light after feeding twice a day. They were merely held under the light of a 75-watt lamp for five-minute periods in order to adapt their eyes to light. Care was taken to prevent them from pecking at anything by holding them firmly in the hand. The behavior of these two groups will be discussed later.

A summary of the different groups and the number of chicks used in the investigation appears in table 1.

IV. METHOD OF PLOTTING CURVES

Unless otherwise stated, all the curves included in this report show only the per cent of successful pecking reactions of the different groups of chicks. In the limited series the curves show the per cent of reaction 4 out of the 75 daily pecks. In the unlimited series no. 1 we took the per cent of reaction 4 out of the total day's pecks. In the unlimited series no. 2, where we obtained the most complete records of the chicks, we plotted the curves for each test showing per cent of successful reactions for the morning, afternoon, and evening test. We also plotted the curve for the total day's pecks as in the unlimited series no. 1. In order to compare our curves with those obtained by other investigators, we plotted the curves for the first 25 and also for the first 50 pecks each day. Then, grouping all the pecks made by each chick into successive units of 100 pecks, regardless of occurrence in different practice periods, we plotted per cents of success in each of these successive units. For cross reference, the position of the end of each day is indicated by crosses on these curves.

V. RESULTS AND DISCUSSION

A. General description of curves

Our attention is directed first to the curves of the chicks in the unlimited series no. 2, where we have complete detailed records of all pecks. Figure 1a and b show the curves of accuracy of 6 of the 9 chicks in the no-delay group (NDS2). The lower curves show their accuracy for the morning, afternoon, and evening tests. The digits mark the evening test, the end of the day. Curves for total day's pecks and curves by samplings of 25 and 50 are not included. The upper curves show the accuracy per 100 pecks. All the curves, with one exception, show a characteristic sudden rise usually preceded by a period of little or no progress, and then a gradual rise to the final level of accuracy. The sudden jump usually occurs the second or third day of practice. To reach the final level, the average (for all NDS2) of days required is 6.2 and the average of total pecks is 1908. The

one exception, chick no. NDS2-3, shows a gradual rise from the first day to the fifth, requiring 1741 pecks to reach its level.

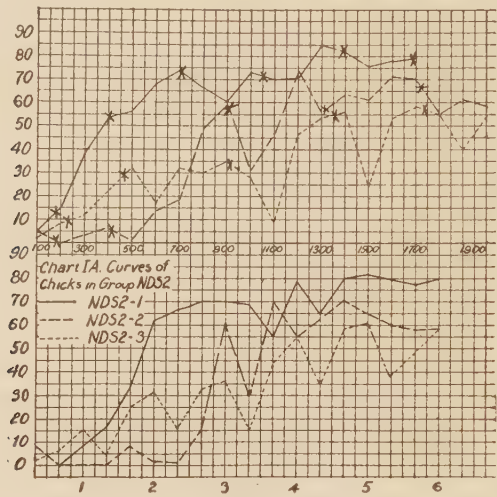


FIG. 1A

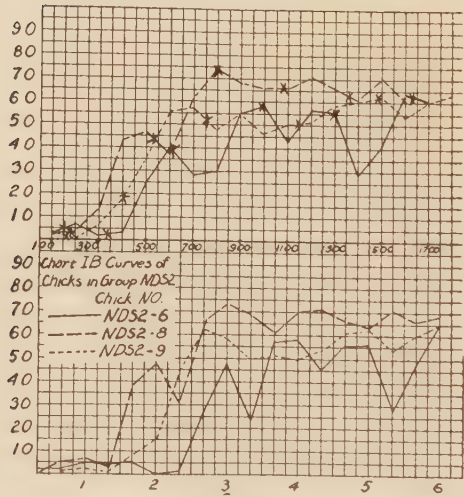


FIG. 1B

Two other typical chicks of this group, nos. NDS2-5 (fig. 2a) and NDS2-7 (fig. 2b) show the typical rapid rise (in number 5 after no-progress period) and then a gradual rise to the final level.

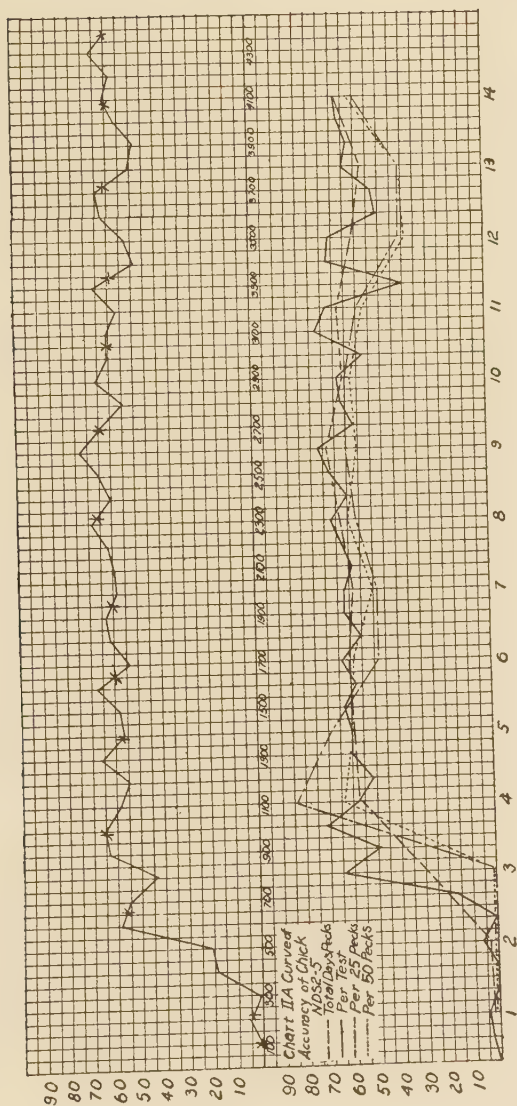


FIG. 2A

The curves for five of the seven chicks in the 8-day group (8DS2) are shown in figure 3a and 3b. Part of these curves exhibit the same sort of a period of quiescence and rapid rise as shown by the chicks in the no-delay group. Figure 4a and b show the curves of two additional of the typical chicks in this group. Chick no. 8DS2-1 (fig. 4a) shows a rapid rise during the first two days and 1014 pecks, and a gradual rise to the fifth day or 2066 pecks. Chick no. 8DS2-5 shows a gradual rise up to the ninth day, requiring 4668 pecks to reach the level of accuracy.

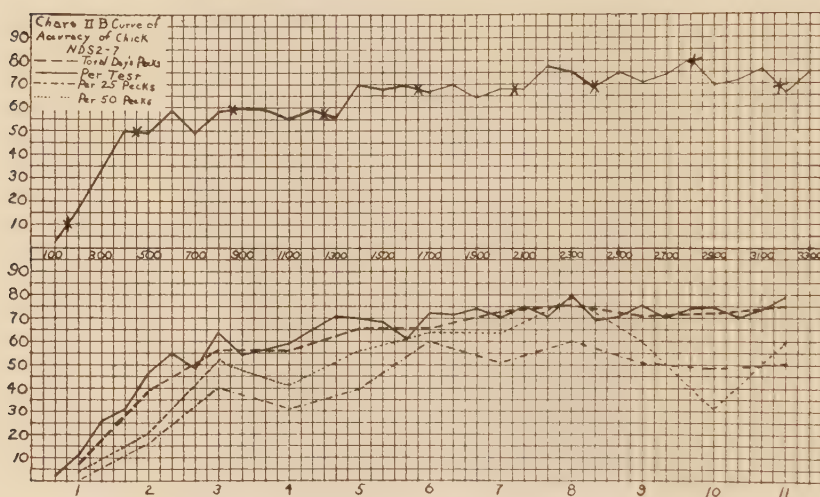


FIG. 2B

In most curves, only the first few days, up to the approximate final level are plotted.

The typical rapid rise in the curves is shown by the chicks in the unlimited series no. 1 (not reproduced), and by some of the chicks in the limited series. One half of the chicks in group NDL show sudden rise in the first three days and only 2 out of 10 chicks in group 4DL show such a behavior.

An interesting result is found when we compare the average time and number of pecks required to reach the top of the rapid rise and the final level of accuracy of the different groups. Table

2 shows that group NDS1 required 4.2 days and 1474 pecks to reach the top of the rapid rise and 7.2 days and 2056 pecks to

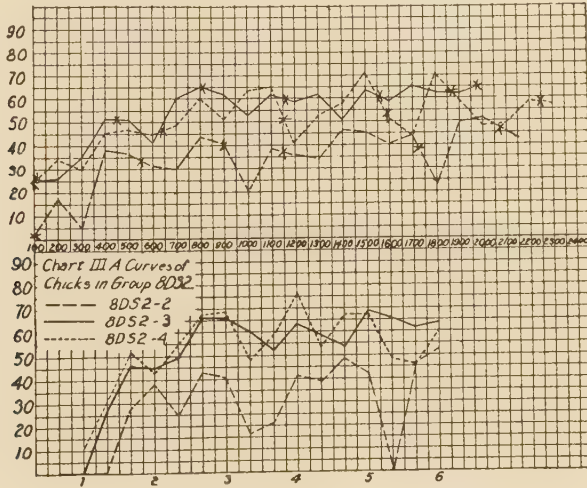


FIG. 3A

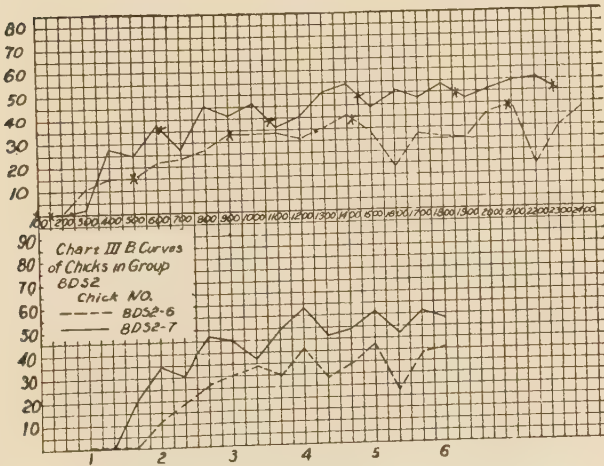


FIG. 3B

reach the final level of 67.3 per cent accuracy. The 4DS1 group required about the same number of days to reach the top of the rapid rise and the final level, but needed more pecks to reach the

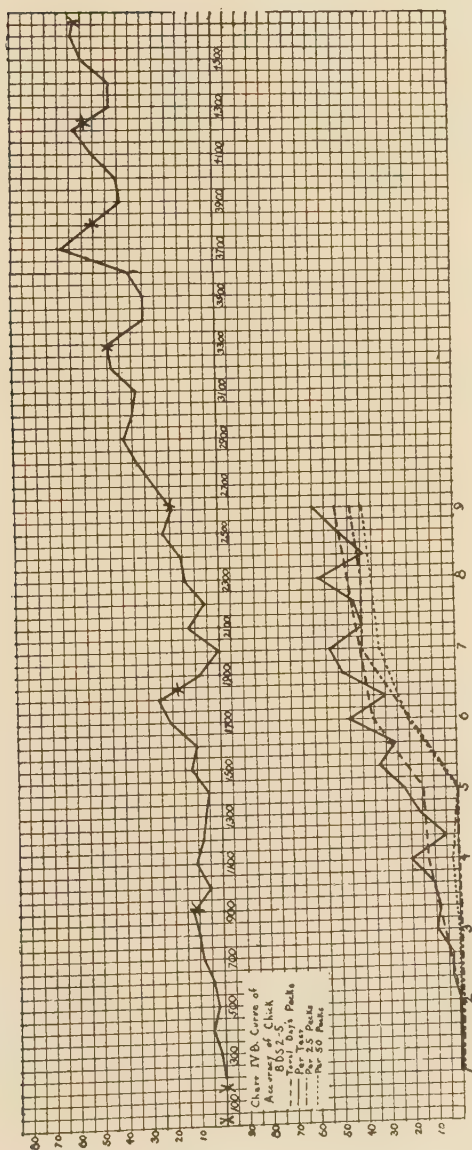


FIG. 4B

level of accuracy of 65.7 per cent which is slightly lower than that of the no-delay group. The 8DS1 group reached the top of the rapid rise and final level in less time, but required more pecks to acquire a still lower rate of accuracy of 55.8 per cent. It appears from our data that the longer delayed chicks required as little or even less time than the no-delays to reach the top of the rapid rise and of the final level, but they required more pecks

TABLE 2

Table showing the average time and number of pecks required to reach the top of rapid rise and the final level of accuracy

GROUP	RAPID RISE IN		FINAL LEVEL IN		PER CENT
	Days	Pecks	Days	Pecks	
NDS1	4.2	1474	7.2	2056	67.3
4DS1	4.16	1595	7	2389	65.7
8DS1	3.6	1954	5.4	2623	55.8
NDS2	3.88	1118	6.2	1908	65
8DS2	3.86	1585	6.5	2699	56

TABLE 3

Table showing average pecks per day

GROUP	1	2	3	4	5	6	7	8	9
NDS1	231	404	376	331	255	229	219	202	212
4DS1	262	517	413	335	297	292	270	253	235
8DS1	399	686	576	468	348	336	350	323	312
NDS2	165	241	369	374	354	319	325	336	303
8DS2	135	411	451	458	514	442	396	408	384

to reach a final level of accuracy which decreased with the increasing length of delay. This is also seen in table 3 which gives the average pecks per day of these same groups of chicks. Here again we find that the longer the chicks are delayed, the more practice pecks they require to reach their level of accuracy.

It is interesting to note that the chicks in series no. 1 on the average pecked more per day at first than did those in series no. 2. This was because, in series no. 1, the chicks were allowed as

many pecks as they cared to make during their tests, whereas those in series no. 2 were allowed to peck until they began to show signs of indifference to the grains, when they were taken back to the brooder and kept until their next test. This was done because it was discovered that in series 1 the chicks, after they had eaten a certain amount, continued to peck at grains but deliberately dropped them. For this reason, in spite of the greater number of pecks they had, group NDS1 did not have as high an

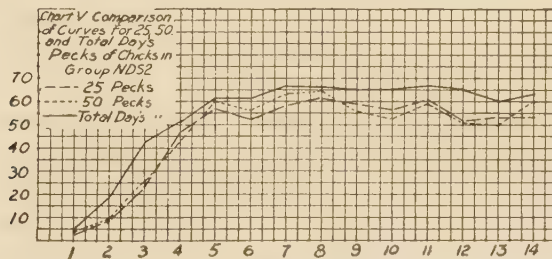


FIG. 5

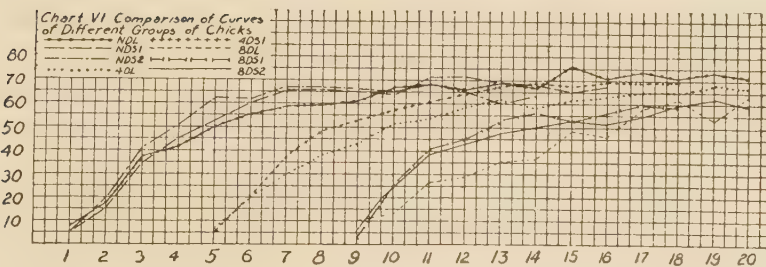


FIG. 6

accuracy during the first seven days as group NDS2 (fig. 6). although the curve of NDS1 in the end rose higher to about 67.3 per cent level while NDS2 had a level of only 65 per cent (table 2),

B. Evidence of warming up

In figures 2a and b, and 4a and b, we find some evidence of warming up during the day's pecks of the chicks. If we follow the records for the morning, afternoon and evening tests, we

find that the chicks' accuracy in the morning is in most cases lower than the accuracy in the afternoon and evening, especially during the first few days of test. This is probably due to the longer period of confinement in the dark previous to the morning test, and to the excited pecking of the chicks caused by hunger. But whatever the explanation, the curves for the first 25 and 50 pecks do not represent the real curve so far as the individual chicks are concerned. If we compare the curves for the 25 and 50 pecks with the real curve for the total day's pecks, the curves for the 25 and 50 pecks are in general lower and more irregular than the curve for the total day's pecks. In figure 4b we find that the first 25 and 50 pecks for the first five days showed practically no improvement, but the curve for the total day's pecks shows some gradual improvement during the five days of test.

Figure 5 shows the curves for the 25 and 50 pecks and the total day's pecks of the 9 chicks in group NDS2. It will be seen that when averaged, the curves for the 25 and 50 pecks are almost parallel to each other but lower than the curve for the total day's pecks. This suggests the inadequacy of taking only a sample of the first 25 or the first 50 pecks as other investigators have done. The real curve of the development of the pecking reaction should be based upon the complete performance of the chicks.

C. The effect of limited and unlimited practice upon the pecking reaction of chicks

To see the effect of the amount of practice upon the accuracy of the pecking reaction, we may compare the average curves for the different groups of chicks as shown in figure 6. It might be added here that the average total day's pecks cover up the rapid rise of curves which is shown when we take the morning, afternoon, and evening tests of single chicks separately. A comparison of the curves of the different groups shows that the chicks in the unlimited series 1 and 2 have almost parallel curves. In the no-delay groups the chicks which were limited to only 75 daily pecks show a curve which coincides with the unlimited groups for the first three days and which reaches the same level

of accuracy as those groups on the tenth day, running only a little lower from the third to the tenth day. This is not true with the 4-day and 8-day groups whose curves run lower than those of the unlimited groups. This is to be expected since, as we have previously noted, the longer the chicks are delayed the greater number of pecks they make to reach their level of accuracy. We would expect that the 4-day and 8-day chicks which were allowed only 75 pecks a day would have a slower rate of development. However, the curves of the chicks in the limited series eventually reached the same level of accuracy as those of the unlimited chicks. This suggests that while in the delayed chicks more practice is needed to reach the level of accuracy, within certain limits the amount of practice does not greatly affect the accuracy of the pecking response. About all one could say as to the effect of the practice is that unlimited practice hastens somewhat the time at which a chick reaches its level. Within the same group, the limited and unlimited chicks both reach the same level of accuracy eventually, even if the limited chick is somewhat slower in reaching such level.

Our normal chicks which were allowed unlimited amount of practice did not attain as high an accuracy as Breed's normal chicks. This is even more significant when we remember that Breed took only 50 sample pecks for each test and we have shown that the curve for the first 50 pecks of our chicks does not represent the true curve of development as does the whole day's pecks. Perhaps there is a real difference between the behavior of our chicks given unlimited practice pecks, and the chicks normally kept in feeding pens as those in Breed's experiment. We can only point to the fact that a careful check-up of this phase of our experiment should be carried further. A more complete record of the chick's development would be obtained if records were taken of every peck made by the chick while in the natural environment of the feeding pen.

Furthermore, as noted above, the curves of the delayed groups in each series do not attain as high a level of accuracy as the no-delay groups. The longer the delay the lower the level of accuracy. This somewhat disagrees with the result obtained by

Shepard and Breed, especially with respect to the 4-day delay groups. However, while our delayed chicks were given unlimited pecks, they were kept in dark boxes when not tested. Shepard and Breed allowed their chicks the freedom of the pen after their period of delay, and in the light of what we have noted above, there is a difference in the accuracy of chicks merely allowed unlimited pecking and those in the feeding pen. This may account for the high accuracy of delayed chicks as found by Shepard and Breed. So far as Moseley's and Bird's results are concerned, their method of force-feeding in the light was such as to make their result hardly a check-up on the result obtained by Shepard and Breed.

Our own results seem, then, to point out that with an increasing length of delay there is a decreasing level of accuracy, accompanied by an increasing amount of practice pecks required to reach the level of accuracy. While no check-up was taken as to the accuracy of the chicks after their final test in the laboratory, it is quite possible that all the chicks, regardless of the number of days of delay, if they started pecking at all, would eventually as they grew older reach the same level of accuracy. Possibly the period of delay serves to retard the rate of development of the pecking response. In the next section we shall discuss further the effect of prolonged delay upon the pecking response of chicks.

D. The effect of prolonged delay

One of the important questions that we had hoped to answer in this investigation was the effect of prolonged delay upon the pecking reactions of chicks. At the outset we had taken for granted that chicks do inherit some sort of pecking instinct; that is, they inherit a pattern of response to a pattern of stimuli. In this case the pattern of response is the pecking reaction, while the pattern of stimuli is the visual stimulus (of the grain) plus hunger. We have also shown that whatever this pecking instinct may be, it is somehow influenced to some degree by maturation and use.

The question might well be asked, how much of the pecking

response is influenced by maturation and how much by practice? Shepard and Breed, who delayed their chicks as long as five days (our 4-day delay) found that the delayed chicks, while they start with a low initial rate, will approximate and even exceed the accuracy rate of the normal ones within two days of practice. They thus claim that maturation is a large factor in the development of the pecking instinct, or rather, that maturation sets the limit of accuracy to which any amount of practice can attain. On the other hand, Moseley delayed her chicks as long as eleven days and found that the longer the chicks were delayed the lower their pecking accuracy as compared to the normal chicks. She concludes that practice rather than maturation is the dominant factor. Bird takes a somewhat middle ground and claims maturation to be effective as a factor only for the first two or three days after hatching, after which the pecking accuracy is largely a matter of practice.

Our own results show that the chicks which were limited to 75 pecks a day and force-fed the rest of their food reached about the same accuracy as the normal chicks. This is especially true of the no-delay chicks. It would seem then that within certain limits the amount of practice does not greatly affect the pecking accuracy of chicks. If it did, then the unlimited chicks which pecked as high as 231 pecks during the first day of test should be just as accurate on the second day of test as the limited chicks on the third or fourth day, since it would take the latter chicks three days to peck 225 pecks. This is not borne out in our results which show that the unlimited chicks take nearly the same time to reach their level of accuracy as the limited ones, in spite of the greater amount of practice. Probably one could select a limit somewhat larger than 75 which would fully equal the unlimited. Maturation, this would suggest, simply sets the physiological level of accuracy of the pecking response, given a certain amount of practice. This approach to the problem needs further investigation.

But there is even a more perplexing problem as to the part played by maturation. If maturation merely sets the physiological level of accuracy of the pecking response, then we might ask,

what would happen to the pecking instinct if we allow the chick to mature physiologically but prevent it from using the pecking response for a longer period? Moseley partly answered this question with her chicks which she delayed eleven days, but she force-fed the chicks in the light, which did not insure them against forming false habits.

The behavior of our delayed chicks afford us some interesting results. Those that were delayed four and eight days, when first brought out to the testing table, were very slow to start; some of them in the latter group did not even start pecking till the second day of test. When they did start, they showed malcoördination of the pecking response. They missed the grains, and their heads wobbled alternately from side to side. Those delayed eight days especially showed this wobbling of the head from one side to the other, missing the grains by approximately 7 or 8 mm. on either side. Some of the chicks continually hit the grain short. Those that succeeded in pecking grains did so only when they placed their bills almost next to the grains before they pecked. This peculiar behavior was not shown in the no-delay chicks. From our observation, the chicks took about two or three days to coördinate their pecking reaction. This malcoördination seems to be typical with those that were delayed eight days.

Seventeen per cent of the pecks of the 8D group on the first day of test were no. 1 (missing) in contrast to less than 5 per cent of the ND group. On the second day, the 8D showed 7 per cent of no. 1, the ND practically none. For most chicks, no. 1 reactions were negligible after the second day; but 8DS2-5 gave 158 no. 1 out of 755 total pecks the third day, 233 out of 929 the fourth day, 240 out of 774 the fifth day, 57 out of 667 the sixth day, and none thereafter. It may also be noted that the delayed chicks make relatively less no. 3 and no. 2 reactions. For the first nine days of test, the 8D chicks gave approximately 48 per cent of no. 2 pecks, 6 per cent of no. 3, and 42 per cent of no. 4; whereas the ND group gave 32 per cent of no. 2, 15 per cent of no. 3, and 52 per cent of no. 4.

One chick from the 8-day group (8DS2-8) was so badly coör-

minated that during two days, in spite of pecking 2324 pecks, it was able to swallow only 13 grains and gave 6 number 3 reactions. The rest of its reactions were missing and hitting. After two days of fruitless effort at pecking, it developed a negative reaction to the grains and refused to peck at all when brought to the testing table on the third day. It was then trained to peck, at first by holding a grain before it and then opening its bill and placing the grain in the forepart of the bill and allowing it to throw it to the back of the mouth, thus giving it the holding and swallowing practice. Even with this training it refused to peck, so another method was adopted.

At this time it was given a mixture of mash and milk in a bowl to peck at. After the chick learned to eat wet mash, the food was gradually hardened and grains added to it so that the chick could not avoid picking up some of the grains. It might be added that the chick was tested at the beginning of each day of training to see if it had learned to peck at grains. On the fourth day of training, the chick learned to peck at the grains in the bowl but would not peck at the grains on the testing table. It was then given a pile of grains on the table from which it pecked. As the pile of grains thinned out, the chick learned to recognize and peck at individual grains. The fifth day it was again tested and its records taken for seven days, at which time it was found that it pecked with an accuracy of 89 per cent, a record even higher than the normal accuracy of its group.

An even more interesting result was obtained from the chicks delayed fourteen days. In the limited series (14DL) we used 21 chicks altogether. Only 3 of these chicks started pecking on their first day of test. Their record for the first six days of test was much lower than that of the other groups. The other 18 chicks were totally indifferent to grains when brought to the table. Some of them readily performed the drinking reaction against the surface of the table and some pecked into the air aimlessly. Some pecked and scratched against the table but never aimed at the grains. For three days these chicks were tested but they refused to peck at the grains. It was thought that they probably were not hungry enough so we stopped the force-feeding and left

them in an artificial pen where they were given plenty of grains and grit to peck at. They all starved to death even in the midst of plenty. Not even hunger plus the visual stimulus of grains could initiate the pecking response.

Because of this unexpected result, we took a group of 5 chicks which we delayed in the same manner. When tested at the fifteenth day, these chicks also refused to peck and, after three days of refusal to peck, we started to train them. The training was similar to that used in training chick 8DS2-8 described above. The chicks were at first given semi-soft mash but they refused to touch it. Since they readily drank we gave them a mixture of milk and mash which they ate as though they were drinking. These chicks were tested at the beginning of each day of training to see if they would learn to peck. For three days they continued to suck their food which was gradually hardened by reducing the amount of milk. On the fourth day they began to peck into the mash so grains were added into the food, but they carefully avoided the grains. It took two more days before they picked the grains from the bowl and on the seventh day they were given just dry grains with mash. The next day they were given only dry grains in the bowl. At this period of training they began to recognize the grains as food when in the bowl but not the grains on the table. On the tenth day the grains were dumped in a pile on the table from which they pecked excitedly. But when the pile of grains thinned out they stopped pecking and the grains had to be piled again before they pecked. We gradually reduced the amount of grains in the pile and on the twelfth day of training three of the chicks started to peck at single grains, but the other two still continued to peck only from the pile of grains until three days later when they also pecked at single grains. The whole period of training was a long and laborious process of two weeks. After that time the chicks were tested and their sample records of about 100 pecks taken daily for the first seven days and every other day thereafter for thirty-four days, so that the chicks were more than nine weeks old at the end of their test. The chicks were allowed to peck naturally in the pen each day after their tests to afford them unlimited amount of practice. In

spite of this unlimited practice and their maturity, and their training, their pecking accuracy remained lower than that of the normal and other delayed groups of chicks. On the average they reached a level slightly above 40 per cent at the end of the test period. They were still on the up-grade at that time, but progress was very slow.

The above result seems to show that the chicks delayed over too long a period tend to lose their pecking instinct; at least, the pecking reaction is so disorganized that it no longer functions. This disintegration of the pecking response seems to start at or before eight days, as shown by the wobbling head and slow start of the chicks delayed eight days. Almost complete disintegration results from being delayed fourteen days. Moseley did not report this peculiarity in her chicks delayed eleven days, and this leads us to believe that her technique in feeding her chicks in the light gave the chicks some practice which she was not able to check.

It might be argued that the loss of the pecking response in the 14-day chicks can be attributed to some physical defect caused by too long confinement in the dark. To this we can answer that our chicks were as healthy as the normal ones. So far as vigor was concerned these chicks were active and were able to run around on the testing table and in the pen. They even flew over the one-foot board used to fence them in the artificial pen. A more convincing evidence that these chicks were not physically defective is found when we compare their weights with those of the chicks in the other groups which had been pecking normally. Table 4 gives us the data for comparison.

The chicks in the no-delay group were weighed in the morning of the ninth day after they had already pecked for eight days and were getting for food only the grains that they could get from the pecking table. The 8-day chicks were weighed on the ninth day after confinement in the dark for eight days, and 14-day chicks were weighed when nine days old, after eight days of forced-feeding. These latter chicks were brought out to the light for two five-minute periods for light adaptation under a 75-watt lamp (described below).

Since no record was taken of the weights of the chicks when only a day old, we can only compare their weights when they were nine days old, and when fifteen days old, the time when the 14-day chicks were brought out for their first test. If now we

TABLE 4
Comparison of weights of chicks used in our experiments

GROUP	CHICK NUMBER	WEIGHT OF CHICKS WHEN WEIGHED AT THE AGE OF		INCREMENT
		9 days	15 days	
No-delay	1	36	39	3
	2	38	42	4
	3	38	44	6
	4	39	41	2
	5	40	44	4
Average.....		38.2	42	3.8
8-day	1	34	38	4
	2	46	49	3
	3	39	42	3
	4	40	43	3
	5	37	41	4
	6	38	41	3
Average.....		39	42.3	3.3
14-day	1	46	49	3
	2	38	44	6
	3	38	46	8
	4	39	49	10
	5	38	47	9
	6	42	48	6
Average.....		40.3	47.3	7

take the increment in weights of the various groups, we find that the no-delay chicks increased only an average of 3.8 grams during the six days of feeding on grains which they were able to peck. Likewise, during the same period the 8-day chicks increased 3.3 grams. The 14-day chicks which had been confined in the

dark and force-fed with a specially prepared food consisting of McCollum's diet and mash moistened with buttermilk and cod liver oil, increased an average of 7 grams. In point of weight then the chicks confined for fourteen days were actually healthier than those in the other groups. Yet, five of the 14-day chicks refused to peck and had to be trained, and even after a long period of training their record was not as high as the record of the normal chicks. It would seem therefore that the deterioration of the pecking response of the chicks that were delayed for fourteen days could not be due to any physical defect since these chicks were even healthier than those in the other groups.

Another question that comes up in connection with the 14-day chicks is with regard to their vision. Our observation of these chicks showed that they were not blind. They were able to walk about the pecking table and they took notice of moving objects. A white grain moved against a black background or a dark grain against a white background evidently attracted their attention since they bent their heads to look at the grain. In spite of that they refused to peck at the grain. This is even strange since some of the chicks when placed together on the table pecked at each other's eyes. From their outward behavior there seemed to be no indication that they had poor vision.

However, we tried to find if there were any defect in the retinal structure of their eyes. We took a chick that had been pecking normally in the light for fourteen days, at which time it had been pecking with high accuracy. We placed this chick in the dark for two hours dark adaptation. We also took one of the chicks that had been kept in the dark for fourteen days. Both animals were given to Mr. Gordon L. Walls, Instructor of Zoölogy, University of Michigan, who very kindly performed the examination of the chicks' eyes. Both animals were killed in the dark. Two techniques were used. One eye from each animal was taken and fixed in Perenyi's fluid for one method. The other eye from each chick was opened, the vitreous drained out, and the open eye-ball fixed by osmic acid vapor for thirty minutes, then placed in 2 per cent osmic acid overnight. All the eyes were embedded in celloidin by the hot method and sectioned at 7.5μ Heidenhain's

hematoxylin plus phloxine was used for staining. Some of the osmic sections were bleached with H_2O_2 before staining.

A comparison of the retinal sections from the eyes of the two chicks by both methods showed no morphological difference in their retinal structures. While this result does not show much, it at least gives us evidence that so far as the rods and cones of the chicks kept in the dark for fourteen days are concerned, there seemed to be no difference between them and those found in the eyes of the chicks normally in the light. We cannot therefore argue that the disintegration of the pecking response of chicks confined in the dark for fourteen days was due to any defect in their visual organs.

Even more convincing than the above test to see if long confinement in the dark was responsible for this disintegration is a second test we made of 14-day chicks. Six chicks (the 14-day chicks of which the weights are given above) were taken and delayed in the same manner as before, except that after each feeding, each chick was brought out to the light and the eyes exposed for five minutes under a 75-watt lamp. Care was taken to prevent the chicks from pecking and to remove all the temptation to peck. This was done by holding the animal in the hand in such a way as to allow only a limited head movement, at the same time exposing the eyes to the light. Two chicks from the 8-day group were treated in the same way during their period of confinement.

Our results show that the two 8-day chicks (8DE-1; 8DE-2) started to peck on their first day of test. The record of 8DE-1 is similar to but not any better than the record normal to the 8-day group, but that of 8DE-2 was even lower than the normal record of the group. In the case of the five chicks in group 14DE, only one started to peck from the first day of test, but its record over the two weeks of pecking was low compared to the records of chicks in the no-delay and 8-day groups. The other four chicks refused to peck even after three days of starving, so they were trained to peck in the same manner as the other 14-day chicks. Their records were the same as those of the other trained 14-day chicks.

Since the two five-minute exposures to the light presumably

allowed these chicks to develop their eyes normally, their refusal to peck could not be caused by visual cell defect due to their long confinement in the dark. This, together with the fact that there is no morphological difference observable in the retinal structures in the eyes of the normal chicks and those of the 14-day group, shows that the disintegration of the pecking response is not due to any defect in the vision of the delayed chicks. The cause must be due simply to the fact that the pattern of response to a pattern of stimuli had not been given any opportunity to operate and the long period of disuse resulted in the deterioration of the pattern.

E. Chicks returned to the dark after pecking with high accuracy

What would happen to the accuracy of chicks if, after acquiring a high accuracy of pecking, they were returned to the dark and given no opportunity to peck again for a certain length of time? We took three chicks that had been pecking for eight days and had attained a high accuracy of pecking. These chicks were returned to their boxes in the dark brooder and were force-fed for fourteen days. At the end of the confinement period we tested them again for their accuracy, taking their records for eight days of pecking as before they were returned to the dark. It was found that all three chicks pecked persistently, but not so effectively. One of the chicks reached its old level of accuracy in four days of pecking. The other two did not return to their old standard, though they reached the level they could attain in three or four days and never improved much after that.

While the above result is not conclusive, it shows that a long period of disuse tends to disorganize the pattern even after that pattern had previously acquired a high level of accuracy. We need, however, to further study the result of putting chicks back in the dark for various periods of delay after having acquired high accuracy of pecking.

VI. SUMMARY OF RESULTS

Some of the important results found in our investigation may be summarized as follows:

1. The curves of the pecking accuracy of chicks in both the no-delay and the 8-day delay groups show a rapid rise the second or third day, usually preceded by a period of little or no progress, and then a gradual rise to the top of the level of accuracy on the fifth to seventh day.

2. Regardless of the length of delay up to eight days, the chicks required about the same number of days to reach the top of the rapid rise and of the level of accuracy, but the longer the delay, the greater the number of pecks which is required to reach the level of accuracy, which level decreases with the increasing length of delay. The longer the delay the less the accuracy.

3. There is a definite warming-up process during the day's pecking of the chicks, particularly during the period of rapid improvement. The accuracy of the morning test is not as high as that of the previous evening at this period.

4. As representative of the real curve of development of pecking, the method of taking only the first 25 or 50 pecks in the morning proves to be inadequate. The more representative curve should be based upon the whole day's performance.

5. The chicks which were limited to 75 pecks a day attained about the same level of accuracy as the corresponding groups of chicks allowed an unlimited amount of practice. This is true especially with the no-delay chicks; but in the case of the 4-day and 8-day groups, the limited chicks required longer time to reach the level attained by the unlimited chicks, although they all eventually reached the same level of accuracy. This suggests that within certain limits practice has very little effect upon the pecking accuracy. What practice does is to smooth the operation of the pecking response. Unlimited practice hastens somewhat the time required by the chick to reach the level of accuracy.

6. Chicks delayed eight days tend to lose the coördination of their pecking response, resulting in the wobbling of the head and in the inaccuracy of pecking.

7. Prolonged delay of fourteen days results in the disintegration of the pecking response to such an extent that most of the chicks never peck, and starve to death even in the midst of plenty. An unusual amount of training and practice would not restore the disorganized pecking response to the level of normal accuracy.

VII. DISCUSSION

A few additional remarks on general theory might be in place. Can we suppose that the failure of the long-delayed animals to peck means that there is no pecking instinct in the first place? But then we have to explain the difference between these chicks and the no-delays. The external necessity is as real in the one case as the other, and the "elemental" movements were at least as much usable in the long-delays as in the no-delays. In fact, part of the delayed chicks did peck fruitlessly into the air and did it continuously and repeatedly for long periods; some struck at the eyes or beaks of others; all watched a moving point, even a moving grain. Briefly, the pecking response seems simply to be disorganized. According to anything we know about learning, there could have been no truly interfering habits; and a resort to interfering habits is a confession that a pattern was present to be inhibited. Practiced chicks returned to the dark showed what was probably the beginning of a similar deterioration. We may suppose that in an animal without previous practice, the pattern could be more easily and more completely disorganized. More work is planned and must be carried out before we can show more definitely the part played by practice, by maturity as a condition of maximum efficiency and by factors of deterioration.

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